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INVENTORY AND ASSESSMENT OF AFRICAN COAL RESOURCES, PRODUCTION AND TRADE IN THE CONTEXT OF REGIONAL AFRICAN DEVELOPMENT

The opinions, figures and estimates set forth in this report are based on information and documents as obtained during studies and missions carried out in the framework of Technical Co-operation between the United Nations Economic Commission for Africa and the Government of the Federal Republic of Germany during the time span from August 1984 to November 1985. They are the responsibility of the author, Dr. G.F. Lange, P. Eng., Regional Advisor to UNECA for the development of coal resources in Africa. They should not necessarily be considered as reflecting the views or carrying the endorsement of the United Nations.

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1. BACKGROUND AND INTRODUCTION

1. In August 1984, UNECA concluded an Agreement with the Federal Republic of Germany for the delegation of an expert on coal development in order to enhance coal development in Africa and to pursue the following objectives:

- To actualize the intended inventory on coal resources, production and trade in Africa.
- To give advice and to assist member States of UNECA in their endeavour to substitute environmentally destructive wood consumption and expensive coal and oil imports by the establishment of indigenous coal production, and
- To advise and to assist member States in their plans and actions to develop coal production facilities for coal export purposes where feasible.

2. The author was delegated from the Federal Republic of Germany to UNECA in Addis Ababa as a Regional Adviser for the development of African coal resources under the mentioned agreement. Since taking up his assignment in September 1984, he carried out two missions to Southern Africa which covered the member States:

- Botswana
- Malawi
- Mozambique
- Swaziland
- Zambia and
- Zimbabwe

3. During these missions and in the course of subsequent follow-up work, he advised the mentioned member States with regard to their respective action programmes in conjunction with the specific coal development activities in their areas:

i) Development of small coal mining and beneficiation projects for the production of household and industry coal brands (cement manufacturing, tobacco and tea drying, textiles, breweries, engineering foundries, etc.) in order to promote the substitution of wood fuel consumption in countries that are environmentally affected by progressing desertification, and to replace excessively expensive and/or unreliable coal imports;

ii) Development of coal mining projects for power generation and/or coal conversion in order to substitute oil, gasoline or power imports and to manufacture fertilizer and explosives;

iii) Development of major coal mining projects for export purposes, also instigating intra African trade, the main purpose of which is to gain much needed foreign currency.

4. While specific reports, containing advice given to member States on their coal related problem areas, have been directed to the concerned Governments on a confidential, restricted distribution basis, this report, dealing with the updating of a general inventory of African coal resources, African coal production, export - and import figures, will be available to all member States. Their specialized agencies, as e.g. the Geological Surveys and the Departments of Mines, are kindly called upon to subsequently contribute to corrections and amendments, in case their reserve and resource assessments as well as their production, export and import figures and specifically their forecasts differ from the figures as presented below. These figures are based on:

- Publications and documents as available in the archives of UNECA,
- information and documents as received by the author during his missions and,
- in the absence of authentic written material or in the case of doubts, on the author's personal judgement.

5. The latter applies specifically to those coal areas which the author could not yet visit in the course of the first year's work of his assignment, i.e. North Africa and Sub-Sahara Africa. Consequently, the inclusion of provisional figures into the attached Table 1 should be seen as a temporary incorporation of orders of magnitude, which has been undertaken to show the major thrust of the developing coal mining economies in various sub-regional parts of Africa. Such a provisional juxta-position, at the present inconclusive status of work, was made in order to enable the reader to draw certain development related conclusions. It is the intent of this study to accentuate inter-related African developments.

6. The preliminary information will be upgraded as soon as all coal related countries will have been visited. If the present figures are not entirely secured, the forecasted figures should be regarded with even more caution. The information as contained in this report is planned to be subject of a renewed publication on the Inventory of African coal early in 1987.

2. PROVISIONAL INVENTORY OF NORTH AFRICAN AND SUB-SAHARA COAL RESOURCES, PRODUCTION AND TRADE

2.1 North Africa

2.1.1 Algeria

7. As mentioned in the preceding section, information and documents on North African coal are not yet available at UNECA at the appropriate and up-to-date accuracy. Consequently, the figures must be regarded as preliminary. This applies predominantly to Algeria. In recent publications, (e.g. in the 1985 Mining Annual Review of the Mining Journal) there are no coal production activities from Algeria recorded anymore. Despite possessing large coal basins (Colomb Bechar, Abdala and Hoggrif), coal production appears to have been discontinued during the second half of the last decade. While in the fifties were still a quarter of a million tonnes of hard coal produced, production amounted only to approximately 120,000 tonnes in the early sixties. However, from 1970 onwards only approximately 15,000 tonnes were produced annually, and the latest recording in ECA at the occasion of the "Regional Workshop on the Role of Coal in accelerated African Economic Growth" in July 1983 shows that from 1976 onward practically all Algerian coal consumption has been imported (approximately 200,000 tonnes until 1978 and 250,000 tonnes in 1979). The last recorded production figure amounts to 5,000 tonnes in 1980.

8. The imports of coal appear to have steeply increased from 1980 onwards, apparently with the increase of steel production. Zaki-El-Hewchi reported in 1983 (for the preceding years?) that 1.2 million tonnes of coking coals were annually imported from USA, West Germany and Poland. The import assessment for 1980 is of a preliminary order of magnitude. It is meant to demonstrate the tendency of growing imports towards 1985 for which year Zaki El-Hewchi is predicting 1.6-1.8 million annual tonnes. However, it is anticipated that a slightly more modest figure will be achieved. These forecasting figures as well as the actual production (zero?) and imports require revision at the occasion of the next mission of the author which is planned to be directed to North Africa in February/March 1986. It is, however, obvious that Algeria has become one of the main African coal importers. There are three main suppliers: USA, West Germany and Poland. The US - and West German coals are presently needed as base components for the optimization of the coke strength. Parts of these blend components could in all probability be replaced in the future by Mozambique coals which have similar blend potentials. This appears to become an excellent opportunity for the enhancement of intra African trade if and when the export potential of Mozambique coals will have been developed. (24)

2.1.2 Egypt

9. Egypt does not yet produce noticeable coal quantities to date. It, however, possesses coal reserves and resources, mainly on the Sinai penninsula. The Ayun Musa deposit is considered to be of no commercial value. 35 Km east of Abu Zemina harbour are the Wadi Bada/Thora deposits situated which are regarded worthwhile to develop. There are approximately 65 million tonnes proven and probable reserves reported (24) which probably can serve as steamcoal.

10. The Maghara coal deposit was discovered in NE Sinai in 1959. Approximately 52 Million tonnes proven and probable reserves (24) are in place and are being developed for production right now. Zaki El-Hewehi expects production start in 1986/87. Mining Annual Review (1985) predicts 600,000 tonnes production per year by 1989. This coal is considered to serve as blend coking coal which can be added to the existing Egyptian coking coal blends at approximately 20% (24).

11. Egypt is already a major coal importing country today. Practically all coking coal requirements of its steelworks are imported from USSR, USA and Australia. Zaki El-Hewehi reports in 1983 coking coal imports of 1.5 million tonnes. The steep increase occurred since 1980 and is expected to reach more than 2 million tonnes during the late eighties.

12. In addition, there will be considerable steam coal imports for a planned coal fired power station on the Gulf of Suez (initial capacity 300 MW), which is expected to burn more than 2 Million tonnes in the early nineties when 1,200 MW will be installed. This powerplant is expected to reach a capacity of 3,900 MW in the year 2000 when 7.8 Million tonnes are required, and even more thereafter, respectively 9.4 Million tonnes of imported steamcoal, at 4,700 MW in the year 2005.

13. It appears to be obvious that in view of the restricted mineable coal reserves and the obviously limited resource potential, Egypt will become a major African coal importer during the next decades. The considerable potentials of other African countries (e. g. Mozambique and probably also Madagascar, see below) for coking coal and for steamcoal exports appear to become a substantial chance for intra-African coal trade with Egypt in the medium and long term future.

2.1.3 Libya

14. There are no coal resources reported in Lybia, neither show the available publications notable coal imports.

2.1.4 Morocco

15. As for other oil importing countries, coal appears to be an attractive alternative for Morocco. There are major reserves in the Jerada coal field in the NE part of the country, situated 10 Km SSW of Oujda. The rank of the coal is anthracitic, consequently it is used for households, small industries and power generation.

16. The production figures increased steadily from approximately 400,000 tonnes per year in the sixties to more than 700,000 tonnes during the early eighties. There are modest amounts of steamcoal and coking coal imports. Due to the installation of the new coal fired power plant Mohammedia at 1300 MW capacity the additional coal requirements will partly be imported.

17. The output of the Jerada mine is intended to be increased from 850,000 tonnes in 1985 to 1 Million tonnes in 1990.

2.1.5 Tunisia

18. This country does not have economically exploitable hard coal resources. Consequently, it is a net coal importer. However, there are a few lignite deposits which were exploited in the past at a small scale, i.e. 41,000 tonnes in 1950 and 8,000 tonnes in 1962. Production stopped thereafter and has not been taken up gain, presumably by economic reasons.

19. The imports of coal are assumed to be rising due to increasing consumption of oven coke and small industries.

2.1.6 Western Sahara

20. No information appears to be available on the coal economics of this country.

2.2 Sub-Sahara Africa

21. All those countries south of the Sahara have been included into this sub-division which could not be visited to date but which are expected to have some coal potential and which are situated outside the SADCC organisation. However, there is no claim for completeness, and the intention was to include the available data of the major coal bearing countries of this category.

2.2.1 Madagascar

22. The coal resources of Madagascar are considerable and the total potential appears to be far in excess of the provisional figure as inserted into Table 1. However, the available records at ECA and other sources do not yet justify a number for a total potential exceeding 500 Million tonnes. The indications are, however, that limited exploration activities in the past do not reveal the true coal potential of this country.

23. A major coal development appears to have been initiated when BP Coal Ltd. signed an agreement with the Government agency Omnis early in 1985 in order to carry out an extensive exploration programme near Tolario in the South West of the island. BP committed itself to spend US$100,000. Its share in the joint venture with the Government will be 49% in any subsequent development. The work commenced in the Betioky district and concentrates on a resource potential of probably more than 500 Million tonnes. The relative short distance to the sea appears to be promising with respect to competitive conditions for a possible future coal export potential. However, there are no published figures available yet as to the expected qualities of this coal. Apparently, at least part of the coal is of a low sulphur content. The ash content as in most Gondwana coals appears to be high (approximately 30%). No coking properties have been observed so far.

24. During the fifties and early sixties, there appears to have been some minor production (2000 to 5000 tonnes per year). Since 1967 any coal production has stopped. There are minor amounts of coal imports suspected, however, no reliable statistics are known as yet.

25. The author intends to include Madagascar into a mission to Central and East African countries in his third year of assignment, i.e. during the second half of 1986. The results of this mission will render the basis for the renewal of this provisional inventory, specifically of the inventory of coal resources for this group of countries.

2.2.2 Namibia

26. Unfortunately, there is no recently published information available on Namibia's coal potential. The geological maps proved that the Permian Karroo formation, which carries coal in many parts of Southern Africa, is available over large areas within Namibia. However, no coal reserves or production figures have been recorded so far in the documents as available to UNECA. Older European Sources report on coal seams which have been penetrated by oil drillings in the North of the country in greater depths (700 m; Friedensburg/Dorsterita 1976) (27).

2.2.3 Niger

27. The most recent publication of coal resources in the Republic of Niger was presented in the West German mining magazin "Glueckauf" of August 1985 (15). There are two hard coal deposits in Niger:

1) Anou - Araren and
2) Salomi

Both deposits are situated near the Uranium deposits of Arlit and Akokan approximately 1000 Km NE of Niamey. The coal at Anou - Araren is being mined for electricity generation. Its heating value is approximately 15 MJ/Kg at an ash content of 50%. Volatile content is 27% (db), Sulphur only 0.5 - 1% (db).

28. The economically mineable opencast reserves are presently defined at 6 Million tonnes. The capacity of the mine is 200,000 tonne per year. The production reaches presently 135,000 tonne per year. The run of mine coal is being crushed in three steps to minus 5 mm and fed into the powerplant consisting of two blocks of each 18.8 MW without further preparation treatment. The powerplant applies the relatively new method of fluidised bed combustion. It will be interesting to observe its performance during the years to come because fluidized bed combustion would be the appropriate answer to sulphur rich coal. By this combustion method the removal of the sulphur can effectively and comparatively economically be achieved by adding limestone to the combustion bed.

29. Fluidized bed combustion should seriously be considered if sulphur rich discards from preparation plants were to be utilised in small units.

30. The hard coal resources at Solomi were detected only in 1982. They are situated in 77 to 660 m depth. Its possible reserves may be enormous and could well exceed the figures as given in Table 1 if future exploration work should confirm this expectation.

31. The openpit mineable reserves of this deposit are estimated at 64 Million tonnes down to a depth of 50 m at a waste coal ratio of averaging 8:1.

32. The ash content of this coal is lower than for Anou-Araren namely approximately 14% (db). The volatile content is higher, at 35% (db). The Heating value of this coal is 30 MJ/Kg(7,200 Kcal/Kg).

33. There are also brown coal resources in Niger which, however, have not yet revealed economic importance (1m seam thickness). Their location at Salkadomo and Tegalol shows only half the distance from Niamey than the hitherto known hard coal deposits. Their heating value appears to be in the neighbourhood of 15 MJ/Kg (3,600 Kcal/Kg).

34. Future prospection work should be directed towards such areas which are nearer to the population centres in the SW of the country in order to disclose coal deposits for the production of household fuel and for the fuel supply for small industries. This could contribute to the urgently required wood fuel substitution.

2.2.4 Nigeria

35. The major known coal resources of Nigeria are located in the goologically known southern part of the country, however, many of them are still in some greater distance from the major population centres. The geological age is reported to be of cretaceous (Companian - Maestrichtian) age.

36. There are tremendous amounts of reserves indicated and inferred The total coal potential of the country appears to be remarkable. However, the figures as presented in Table 1 must be regarded as preliminary until the author could get into direct contact with the authorities during the next mission to North and West Africa early in 1986. The presently available information and documents cannot be regarded to be exhaustive and up-to-date.

37. The known coal measures outcrop along the Enugu escarpment following the towns Nsukka, Ezimo and Okaba. Further to the NE is the occurence of Lafia-Obi where reportedly 22 Million tonnes of coking coals are indicated. Much further to the NE of the country, in the Bauchi State, there appears to be geological exploration under way in order to confirm further coking coal deposits. The great overland distances to the main consumers appear to be an obstacle which must be overcome if further developments of these coking coal resources are intended (Unit trains ?).

38. The qualities of the major Nigerian coal deposits are in the steam coal category. They are of comparatively low ash content (8-22%, d.b.). but of high volatibility (36-44%, d.b.). The net calorific value is ranging between 6,000 and 6,400 Kcal/Kg (25-27 MJ/Kg). The sulphur content is reported to be below 1% (d.b.)..

39. The Lafia-Obi coking coals have a slightly higher ash content (27%,d.b.) but are of low to medium volatile matter quality (21-22%, d.b.).

40. Its Sulphur content averages around 2% (d.b.). It is not known whether or not it consists mainly of anorganic sulphur in order to assess the possibility of reducing it to acceptable levels by beneficiation methods. The calorific value lies slightly above 6,000 Kcal/Kg (25 MJ/Kg). The swelling index is reported to be 6, which indicated (at the high ash percentage) fair coking properties, which, however, must be tested in the semi-industrial scale and in blends with other coals before a conclusion about the cokeability of this coal can be drawn.

41. The annual coal production figures in Nigeria have reached more than 600,000 tonnes before the civil war in the sixties. Thereafter, in the seventies, the production averaged at 235,000 tonnes per year until 1976 and declined thereafter to an average of 165,000 tonnes and 120,000 tonnes in 1981(7). In 1984, 83,461 tonnes were most recently recorded (9) which indicates that the 500,000 tonnes as anticipated for 1985 will probably not be reached. The production is reported to be hampered by "the lack of spareparts, inadequate supplies of explosives, power, safety appliances and finances" (9). The producing mines are Owukpa (24,128 t), Onyeama (23,898 t), Okpara (22,769 t) and Okaba (12,666 t). The major consumers are the National Electric Power Authority (NEPA), the Nigerian Railway Corp. and the Nkalagu Cement Co.

42. The ambitious development and expansion programmes which included extensive underground drivages, new long wall faces and the development of various new coal fields anticipated 3.8 Million tonnes production in 1986(16). The much more modestly estimated forecasts in Table 1 do reflect the recent predicament, but anticipate fast rehabilitation.

43. The in 1982 projected coal demand (16) foresaw nearly 2,5 Million tonnes of coal consumption in 1985. In the absence of coking coal production, major imports were predicted to supply the new Ajaokuta Steel works which were supposed to start production in 1985. Zaki El-Hewehi forecasted in 1983 (24) 1.2 Million tonnes of coking coal imports per year for Ajaokuta in its first production stage and more than 2 Million tonnes thereafter. This has provisionally been considered in Table 1. However, these optimistic forecasts require revision in the light of recent developments. This revision will be done during the author's next mission in Spring 1986.

44. In addition to its extensive hard coal reserves, Nigeria possesses also substantial lignite deposits (of tertiary age, miocene) which are known in the South of the country. There are 250 Million tonnes reserves reported to be in place. Their calorific value is recorded to be averaging around 5,000 Kcal/Kg (21 MJ/Kg). These lignites appear to be well suited for power generation and hydrogenation (16).

2.2.5 Uganda

45. It is assumed that Uganda is having some coal resources but no relevant documents could be located in UNECA as yet. Therefore, the recently published resource figure as issued by the Mineral Resources Unit of the Natural Resources Division early in 1985 have been inserted into Table 1. The verification or amendment of this figure will be attempted by 1987.

2.2.6 Zaire

46. Friedensburg - Dorstewitz (27) published in 1976 one billion tonnes of coal reserves in Zaire. Considering the generally reliable information from this source, this figure has been inserted into Table 1. However, during the intended mission to Central Africa in the Fall of 1986, this provisional figure will have to be re-checked and amended.

47. Coal occurs in Zaire in the Carroo (Ecca) Formation of Permian age. Two coal fields are as yet known in the Shaba (Katanga) province:

1) The Lukuga and Tanganyika coal deposits in the north and

2) The Luena and Upper Lualaba in the south.

48. The qualities of these coals are reported to be of high volatile (30-34%) and medium ash content (15-16%). There are no coking qualities known as yet, and the coke as required for copper smelting must be imported from Wankie Colliery in Zimbabwe (1,200 Km distance).

49. Production takes place in the South at Luena, where it started as early as 1922. There are conflicting figures as to the yearly output. They may have been amounted to more than 200,000 tonnes in the fifties. The production in the Lukuga basin West of Albertville is reported to have been 290,000 tonnes in 1960 (7). Dorstewitz (27) shows smaller figures for the overall production which deteriorated from 180,000 tonnes in 1960 down to around 100,000 tonnes in the seventies. This order of magnitude was maintained until 1980 by the recent UNECA reporting (7). Slight increases are predicted for the decade of the eighties.

50. Imports of coal and coke are reported at an order of magnitude of approximately 200,000 tonnes coal equivalent in 1980. This figure consists of 90,000 tonnes coke, which is deemed to be equivalent to approximately 130,000 tonnes coking coal and 70,000 tonnes of hard coal briquettes. It is expected that these figures will slightly rise until 1990 (2-3% per year).

3. INVENTORY OF SOUTHERN AFRICAN COAL RESOURCES, - PRODUCTION AND - TRADE

51. As mentioned in the introduction, the first two missions within the author's assignment were carried out in Southern Africa. Consequently, the figures as presented in Figure 1 for this subregion are more reliable than those for the preceeding sections. However, the summarizing approach as taken in these chapters will be maintained also for the discussions on Southern African coal conditions and prospects. Detailed figures and descriptions on reserve areas, quantities and qualities as well as on mining activities are filed in the Natural Resources Division of UNECA and will be published

in the frame work of the overall African coal inventory when comparable information will be available for all coal bearing African countries. As mentioned above, this will presumably be the case during the third year of the assignment, early in 1987.

3.1 SADCC Countries

3.1.1 Angola

52. The first country which the author intended to visit under his assignment was Angola, because energy related studies are co-ordinated for SADCC in Luanda. Unfortunately, probably due to communication difficulties, a contact to SADCC could not be established, and the flight connections into and out of Luanda could not be assured, so that a punctual and reliable performance at the beginning of the travel schedule of the Mission No. 1 was not safeguarded and thus could have jeopardized the further proceeding on the trip. The contact with the SADCC energy sector had consequently to be postponed until better communications and reliable travel connections will have been established.

53. No hard coal deposits at acceptable qualities are known in Angola. However, the presence of Permian Karroo-sediments in the NE of the country indicate that it may not be impossible to find exploitable coal deposits in the future(28). In the coastal region, there are some low-quality brown coals (Libalites) which, however, are not exploited.

54. There are no imports of coals recorded.

3.1.2 Botswana

55. Very extensive resources of high ash, medium calorific value coal resources are situated in Botswana. The Kalahari Karoo basin underlies 60% of the country. Exploration work has been done by various international companies and was concentrated mainly at the eastern and southern flanks of the Karoo basin. Project studies have been carried out within the Morupule - Serowe area in the East of the country and in the more southerly situated Mmamabula area. Further studies are in progress north of Morupule. The overall resource figure is with 19.9 Billion tonnes well documented (3). There are far more than 20 billion tonnes expected as a total resources potential. The proven and

indicated reserves which were partly included into intensive mine planning studies amount to 7.9 billion tonnes in situ in the Morupule area, 1.3 billion in SW Maijabana and 5.2 billion in Mmamabula. Further indicated reserves are at Letlhakeng and Dutlwe.

56. The qualities of Botswana's in situ coal resources are of high ash, medium to high volatile and partly of high sulphur contents. However, washing of these coals is yielding a saleable product which (at 50% yield) contains only moderate ash contents (14%, d.b.) low sulphur (below 1%, d.b.) and a calorific value of above 27.5 MJ/Kg, i.e. 6,500 Kcal/Kg. The volatile matter contents vary between 32 and 38%. It has been established that major parts of these coals are of exportable quality, but that the high costs of infrastructure and transportation to tide-water are under present world market conditions prohibitive for a major export development. Under optimized conditions*), Botswana coals do have a chance to be internationally marketable when a new upheaval of the international coal market prices should occur. On the basis of generally available market information, it is assessed (and published by Shell) that this could become reality around the year 2000.

57. Major studies showed that a rail link to Walvis Bay in Namibia is technically feasible, though economically prolematic, and would require significant amounts of coal to be exported via this new rail connection to the West coast of Southern Africa in order to secure economic feasibility.

58. If only a few million tonnes should initially be exported, a rail connection to the South East could provide economically optimized access to the coal terminal Richards Bay at the Indian Ocean (29).

59. While the foregoing explanations refer to vague future prospects, there is already a producing coal mine established near Morupule by a private enterprise with international technical and managerial backup, which is presently producing more than 400,000 tonnes coal per year at competitive prices. Its capacity is being enlarged to 480,000 tonnes in 1985 in order to meet the increasing demand of a new 90 MW mine mouth power station at Morupule. The mine is conventionally equipped, i.e. mechanized, and showed a performance per manshift of 7.5 tonnes during recent years. Its capacity can be enlarged to 600,000 tonnes per year with minor capital supplements and beyond if the local market will expand.

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* As recommended by the author in a specific report with restricted distribution to the Botswana Government of June 1985.

60. The establishment of a preparation plant is under discussion and investigation by a technical aid project, sponsored by the Federal Republic of Germany, in order to offer Morupule washed coal in the local markets for households and small industries. The problem of growing desertification in the wake of excessive wood consumption in the country will have to be tackled by offering competitive coal brands for woodfuel replacement (1).

61. A further chance for an increase of the local coal market in Botswana appears to be the planned commercial exploitation of the Sua Pan soda ash deposits where an international company will develop and manage a major soda ash export project, which will internationally be financed (9).

62. Botswana is an importer of coal because the present quality of Morupule coal does not suffice for local industries (Meat Board, Breweries etc.). This may rapidly change if and when the afore-mentioned preparation plant project will successfully be implemented. In Table 1 this has been envisaged for the year 1990 and thereafter.

3.1.3 Lesotho

63. There is no information on hard coal in Lesotho available. The author had intended to visit Lesotho in the course of his Mission No. 2 to Southern African States and approached the Government, however, no response was obtained in time in order to fit such a visit into the travel plan.

64. Major parts of the country are covered by the Jurassic Drakensberg lava. In a few parts, however, is the Permian Karroo formation exposed, where hard coal occurrences are reported (27, 28). The poor infrastructure, the rugged terrain and the generally insufficient development status may have contributed to the lack of coal mining development. It is hoped that future budget constraints do not prevent the UNECA-FRG technical co-operation project from again attempting to include this country into the frame work of advising activities for coal exploration.

3.1.4 Malawi

65. There are coal deposits in Malawi, however, their geographical distribution was not conducive for early development. Consequently, Malawi relied for its present demand of approximately 75,000 tonnes coal per year on imports from neighbouring Mozambique, Zimbabwe, Zambia, and South Africa. Unfortunately, these deliveries are not regarded to be reliable anymore. The economy of Malawi is severely suffering from coal delivery interruptions. The costs to the economy on account of this situation are enormous. The Government consequently decided on developing the coal resources of the country for indigenous production and deliveries to the Southern industries despite their remote location in the North.

66. The country has various coal occurences and deposits which have been under geological investigation for many years. The Southern coal fields Lengwe and Chiromo, which are near to the coal consuming industries, appear to be situated at the eastern rim of the Mozambique coal deposits at Tete - Moatize, which in its center region generally contain mighty coal seams (see below). At their eastern rim in Malawi these coal measures appear to be thin and deteriorating in quality. In addition, there are intensified tectonic disturbances. The quality features, specifically the heating values, appear to be erratic and inconsistent (4 to 24 MJ/Kg, i.e. 900-5700 Kcal/Kg). Based on the present knowledge the Malawi Geological Survey does not assess these areas as promising for coal mining development (4).

67. The coal deposit at Livingstonia in the North of the country near the Lake Malawi is of restricted magnitude but easily accessible near the lake shore. There are up to 270,000 tonnes in situ coal reserves which are presently mined as "stop gap measure" in order to remedy the prevailing coal shortage. The average heating value of this coal is expected to be approximately 4,800 Kcal/Kg (i.e. 20 MJ/Kg).

68. In view of the restricted reserves, these mining activities can, of course, not be regarded as intermediate and longterm solutions.

69. There are further coal deposits in the North which are difficult to access, e.g. North Rukuru, Nthalire, Kibwe, Lufira, Mwenkenje Mwapu - Mwesia, Mwenewenga - Sekwa, Hara, Vwazo Marsh and the Karonga concealed Coal field. Prudent geological and mining engineering as well as access reasons exclude these deposits from immediate development.

70. The Ngana coal field appears to be the most promissing resource for development. It is, however, situated at the northern most boundary of the country and constitutes the southern extension of the Songwe-Kiwira Coal field of Tanzania. Its coal beds are dipping 10-33° (east and south) and are part of an L-shaped syncline which is fault bounded. Its qualities are considered to average at 30% ash and 25% volatile matter content. The calorific value is about 20 MJ/Kg (4,700 Kcal/Kg). The sulphur content of the raw coal was analyzed at 2.2% averaging, however, if this coal were washed the sulphur content in the clean coal could be reduced to below 1%. Its major part is apparently pyritic.

71. It is estimated that there are 50 million tonnes of coal resources in situ down to a depth of 200 m. According to sound geological conclusions there are additional resources in greater depth anticipated. The drill indicated reserves amount to 15 million tonnes which can be mined by underground and open cast mining methods.

72. There are previously established feasibility studies which need to be upgraded in order to become applicable to 1985/86 conditions. The Government of Malawi intends to build a mine and a preparation plant at Ngana and to ship the clean coal via the Lake Malawi from Kaporo in the North to Chipoka in the South from where railway connection exists to the industrial center of Blantyre. The initial capacity of the Ngana coal mine will probably be 100,000 tonnes clean coal per year which will be expanded according to market conditions.

73. The development of the Ngana coal mine appears to be justified mainly by the enormous costs to the economy of Malawi caused by continued delivery interruptions. No intermediate term anticipation of permanent normalisation of coal imports from neighbouring countries is anticipated by the authorities. Even if in the future coal imports should become possible, reliable and competitive again, the Government apparently intends to continuously support coal deliveries from a secure indigenous source.

74. For comparison purposes it may be useful here to note that the Governments of several industrialized nations, specifically of the Federal Republic of Germany, place utmost importance on the security of coal deliveries to cokeovens, power-plants and other industries. These governments are partly even prepared to subsidize indigenous coal production by reason of the required reliability and security of energy supplies. It might be regarded as a price to be paid by the Nation for a more secure energy environment as the basis for uninterrupted prosperous industrial development. Similar conditions could quite well arise also for Malawi in the future.

75. Of further importance and justification for the development of a coal mine in Malawi's North is the least development status of this part of the country. The establishment of a thermal powerplant, preferably on the basis of discards from the washed product, is taken into consideration, without, however, affecting the swift planning and establishment of the mine, the preparation plant and the transportation chain to the southern industries. This would also contribute to reducing expensive consumption of imported diesel fuel for power generation at the mine and within the area. It would also contribute to improved economics of the mine by adding revenues from the sales of discards to the power plant.

76. The Malawi Government has founded a Development Company, MIDCOR (Mining Investment and Development Corporation), which will be responsible for the development of mining and mineral processing projects. Its first and foremost task will be coal resource development, possibly supported by technical aid programmes.

3.1.5 Mozambique

77. Mozambique's coal deposits at Moatize in the Tete province are ranking among the best in Africa with regard to quality, specifically to the excellent coking properties (FSJ 8-9 if washed coal), and with regard to its extensive openpit potential. The coal resources belong, as elsewhere in Southern Africa, to the Permian Karroo formation. Its ash contents vary within the main seam, the Chipanga seam of partly upto 40 m thickness, between 14 and 23%. Its low to medium volatile matter content mainly varies between 16 and slightly above 20%. The sulphur content remains normally below 1%(27). Its washability properties facilitate the beneficiation of a comparatively low ash containing coking coal product and a steamcoal product which may also be sold in international markets (2).

78. There are huge quantities available of which only a fraction is being mined by low performance underground methods. Until recently, only two of the previous 5 mines were in operation. Due to exhaustion and due to two Methan and coal dust explosions in 1976/77, four mines were completely abandoned. The production at its peak reached 534,500 tonnes in 1981. Thereafter, the operations could not be maintained at normal pace and came practically to a standstill due to economic difficulties and to the activities of armed rebels. Minor tonnages were sporadically sold to Malawi over a road connection which was protected by armoured Zimbabwe army units in guarded convoys. Nowadays, even these deliveries came to a standstill.

79. A study compiled in 1977 resulted in 800 million tonnes openpit mineable reserves in selected areas outside the present underground mining areas along the outcrops near the village of Moatize. Another study reaches the overall figure of over 1 billion tonnes including the present underground mining areas (most of which are still available for high performance low cost openpit operations).

80. If mined by underground methods, only a fraction of these reserve figures is exploitable because only a slice of 5 m of the 20 to 40 m mighty Chipanga seam can be mined by underground methods. Of this slice only 30 per cent are recovered (due to the necessary pillars) as run of mine coal, which in the end amounts to approximately only 5 per cent of the in situ coal reserves.

81. There are further coal seams in adjacent areas. One coal bearing horizon has been discovered at the northbank of the Cabora Bassa Reservoir, another near the boundary to Malawi. The overall coal resource potential of Mozambique will exceed the above mentioned figure by far (possibly more than 2 billion tonnes in situ).

82. The relatively modest distance to the sea (574 Km to Beira on rail), the excellent cokability and the extensive openpit mineability are factors which appear to justify a large-scale development under long-term aspects, even in view of the intermediate term oversupply situation in the international coal markets. The anticipated excellent blend potential of Moatize coking coals should be of interest to coking coal importing countries as e.g. to the mediterranean rim countries and also to such countries in Africa where good quality coking coals are rare, as e.g. to Nigeria, Egypt, Algeria and Nigeria.

83. The Mozambique Ministry of Mineral Resources' intention is to open up Mozambique's mining industry towards foreign investors, preferably with "hard currency" at their disposal, in order to initiate a more successful development than hitherto achieved.

84. The recently obtained performance figures shows a certain technological backlog prevailing here, if we compare them with those of neighbouring countries under comparable geological conditions. The average output per manshift figure, as these mines have experienced under the infrastructural conditions during recent years (since 1978)[1], was 0.7 to 0.8 tonnes per manshift, i.e. only 30% in comparison to Zimbabwe underground mining and 10% in comparison to Botswana underground mining.

1/ The performance before 1978 was higher, i.e. 1.69 tonne per manshift in 1973, deteriorating to 0.94 tonne per manshift in 1977 (mine desaster in Chipanga 3).

85. It is mainly the difference in the technological and operational layout of the Moatize underground mines in comparison to the layout of modern mines in neighbouring Africa, (in North America, or Australia) which are applying "state of the art" conventional coal mining methods and equipment.

86. The mentioned performance gap and the considerable cost disadvantage deduced therefrom in comparison with competing African and Overseas coal mines clearly illustrate why the Government of Mozambique must have a vital interest to attract foreign capital inflow, modern mining technology, and advanced management to reorganize and rehabilitate Moatize coal mining in order to become competitive for export purposes.

87. But it is not only the handicapped technological and economic status of the Moatize underground coal mines that causes the desire of the Mozambique Government to reform its coal mining ventures, it is also the fact that there is a tremendous, so far unused, low cost openpit mining potential that can be developed at various sections of the huge deposit. The capital intensive nature of such a development and the high financial risk appear to necessitate the involvement of experienced international mining operators that would have the confidence of potential hard currency customers who are prepared to participate in and/or to help financing such a major investment.

88. There is also the requirement of a minimum tonnage to be produced and to be shipped to the sea and to customers in order to justify the enormous infrastructure investment for unit train operations and harbour development. The entire complex of optimised large-scale mining ventures, including the important beneficiation aspects, the required infrastructure and the tremendous marketing efforts to secure the future sales of the respective coal products and quantities, will have thoroughly to be investigated in detail and under overriding economic aspects within integrated bankable feasibility studies. Such ventures certainly require the expertise, experience, and corporate background of effective Project co-ordination on the side of Government and industries in order to secure the required integrated conception and successful completion of such a potential mega project complex in Africa.

89. A large mediterranean industrial group has meanwhile concluded a contract with the Ministry of Mineral Resources on the feasibility studies for a part of the Moatize coal deposits, that could be developed for coking coal deliveries to mediterranean steelmills and for steam coal deliveries to other industrialized countries.

90. In connection with this contract amounting to several million US Dollars; a letter of intend has been signed confirming that one country would take a major yearly amount of coking coal if and when the project come to fruition. This approach, which takes into consideration the present practicability and the specific interest of a potential major customer, will doubtlessly result in a feasibility study for a part of the huge project area, comparable to previous studies which have been carried out by various International consultants. It is hoped that an overriding approach, co-ordinating all international efforts to initiate coal development in Moatize, will be attempted during and after the elaboration of this new feasibility study. It is felt that the Government of Mozambique will not loose sight of such an all encompassing co-ordinating effort in the interest of optimization for future developments, specifically with respect to maximizing a share in the international and intra African markets and to the required establishment of a reliable sufficiently sized transportation and shiploading infrastructue.

91. It appears to be the thrust of the initiated activities that the years of unrest and economic stagnation in Mozambique should effectively be used to prepare the country for a successful development of its abundant coal - and other raw material resources for a time in the future when the conditions have improved.

92. As mentioned above, the export figures come practically to a stand-still in 1985. In Table 1 it is expected that some rehabilitation will be achieved by 1990. However, the major internationally sponsored export development as indicated above, will probably take effect with major quantities only after 1990. The establishment of feasibility studies and master plans and the development of the mines, preparation plants and infra-structures will require much more time than five years.

93. Mozambique is also a coal importing country. The transport and cost advantages for the Transvaal coals CIF Maputo render the Moatize coals less competitive in the southern regions of the country. It is hoped that this will become different when Moatize coal brands will be expected from Beira during the next decades.

3.1.6 Swaziland

94. The total coal resources potential in Swaziland is estimated at 5 billion tonnes in situ. A major part of it is mineable. The qualities are mainly of authracitic character up to low volatile content. The ash contents are around 25 % in raw coal sulphur is low, partly less than 0.5%. Calorific values in raw coals are seldom less than 23 MJ/Kg (5,500 Kcal/Kg). If washed, an export quality product of approximately 12% ash can be produced at 30MJ/Kg (7,200 Kcal/Kg) and in certain cases more than 50% yield. The discards of such an export product could contain a heating value of approximately 24 MJ/Kg (5,700 Kcal/Kg) and could be used for power generation.

95. One underground coal mine, the Hpaka mine is now producing for more than 10 years. Its present yearly capacity is 220,000 tonnes. More than 100,000 tonnes are expected to be exported to Kenia, where this coal is used for cement manufacturing. Its volatile matter content is 11-14%, the ash content 19-24%, its sulphur content less than 1% and its calorific value 26 to 27.4 MJ/Kg (6,200-6,500 Kcal/Kg). The domestic sales of presently around 26,000 tonnes go to brick works, sugar mills and households. There are cobbles, nuts and peas, of which the ash content varies between 15 and 17%, the volatile content around 10% and the heating value near 29 MJ/Kg (6,900 Kcal/Kg). The overall sales yield is 75%.

96. The mine is not mechanized. Consequently, the output per manshift is low in comparison to mechanized mines, i.e. 2.2 t/MS; however, the costs per tonne are low as well due to low labour and material costs. Consequently, the mine is working competitively at an inland price of approximately E/t32 and at an export price of FOB Maputo of E/t 37 in 1985. Approximately 330 Swazis find permanent employment here. The export coal is shipped by rail to Maputo and is loaded there into seagoing vessels for the shipment to Kenia.

97. It is the intention of the Government of Swaziland to establish a thermal power station on the basis of coal in order to reduce its dependency on hydro-power and electricity imports. Negotiations with different operating and design companies for the development of a coal mine on the one side and of a mine mouth thermal power station on the other side are being conducted. Size and design parameters of mine and power plant have not yet been finally determined. The establishment of an all inclusive feasibility study, embracing the many aspects of such a multi faceted project, appears to be of importance. The Government of Swaziland intends to acquire sizeable shares in the mining comapny as well as in the thermal power plant and will be in control of the overall objectives and of the setting of priorities and guidelines for this project's design and development.

98. It will be a further task for the aforementioned comprehensive feasibility study to check whether the design of a power plant on the basis of discards, i.e. here of a high ash containing fuel product, was technically feasible and at which penalties, and whether the overall mining - power plant project did, in fact, show better economic results if a prime export coal brand could be diverted into the international and intra African coal markets. The feasibility study in this case had to be extended beyond the above mentioned disciplines into the assessment of a sizeable coal market for the respective coal brand. In the case of a favourable technical and economical feasibility of such an extended coal mining and thermal power project, its value and importance to the Swazi Nation would greatly be enhanced in terms of additional (hard currency) revenues and job creation. Moreover, the then probably much greater quantities of export coal, then being produced and marketed at present, could in all probability, in combination with the presently established new North - South Railway line, enable the coal company to ship its coal brands to tide water at much lower costs with the aid of unit trains. These transport conditions will have to be investigated within the framework of the required feasibility study.

99. In view of the still undetermined size of the new powerplant and of the export possibilities, it has been anticipated in Table 1 that an expansion of coal production at the existing Mpaka mine by approximately 30,000 tonnes per year does not seem to be unreasonable and that also exports will increase considerably. It is, however, well possible that the afore-mentioned development scheme will require more time than the provisionally anticipated 5 years.

3.1.7 Tanzania

100. According to the documents, as available in UNECA on Tanzania coal resources (12,9), there are eight coalfields in Tanzania, namely Songwe-Kiwira (near the Malawi border north of Lake Malawi, Ketewaka-Mchuduma, Ngaha, Njuga, Nhukuru, Mbamba-Bay, Galula, and Kiwete. The inferred reserves are estimated at 1.5 billion tonnes in situ of which between 300 and 400 million tonnes appear to be mineable.

101. The coals in Tanzania are generally, as the coals in Southern Africa, of Gondwana origin and of Permian age. They are medium to high volatile bituminous coals of medium ash contents (14-20%, d.b.) the sulphur contents appear to be low (below 1%) in most cases. However, in exceptional cases, also high sulphur values are recorded (up to 7%, e.g. Namwele-Mkomolo). The coal resources in Tanzania are mainly situated in the south-western parts of the country and are mainly disclosed in the northern and easterly neighbourhood of the Lake Malawi (Rift Valley). With the help of the Chinese,

the Kiwira coal mine is being established with the aim of producing 150,000 tonnes in 1988. The present production at the Ilima Colliery totals approximately 10,000 tonnes per year.

102. A comprehensive feasibility study is underway on the expansion of the Ilima Colliery within the context of a general evaluation of the Songwa - Kiwira coal field. The World Bank is funding these studies (at US$19.35 million), of which a major objective is to increase the present production to 48,000 tonnes per year (9). This coal will be used in the Tukuju based tea factories in the neighbouring Mbeja region. A major openpit is being considered at Kabulu Ridge where the objective is to produce 500,000 tonnes per year in the more distant future.

103. The forecasts as inserted into Table 1 consider the establishment of a production figure of 150,000 tonnes per year by 1990. Further increases are possible thereafter.

104. Reference should also be made to the plans for a steelmill at Mutindi (east of Lake Malawi south of Njombe) for which coking coals have been explored at neighbouring Mchuchuma. The iron ore supply is planned to be established from the Lingango deposit. No recent information is available on the status of the project. For the year 1990 this project will in all probability not yet contribute to any coal production forecast. A publication in African Business of June 1984 (30) reveals that the available iron ore was not suitable for the anticipated direct reduction process because of its chrome content. Such ore would better be suitable for a stainless steel plant which is, however, not under consideration.

3.1.8 Zambia

105. Zambia possesses a considerable coal resources potential, as elsewhere in Southern Africa of Permian age. The coal deposits in the generally north easterly strike direction of the Ecca horizon reach from the southern most corner of the country to its border with Tanzania and Malawi. Due to partly inaccessible terrain and consequently insufficient exploration, mainly the South-Western part of the coal resources are sufficiently explored in order to prove and indicate major amounts of mineable coal reserves (12). The major part of the 95 million tonnes in situ mineable reserves, as inserted into Table 1, are proven and indicated in the Kasinze and Izuma basins in the Maamba coal mine area namely approximately 70 million tonnes. The remainder has been explored at Kandabwe (20 million tonnes) and Mulumjera

(5 million tonnes); both areas are neighbouring the wider Maamba mine area to the north and to the south. The in situ qualities of Zambia's South Western coal deposits in the mid Zambesi Valley are defined as low volatile matter bituminous coals (19-20% d.b.) with generally medium ash contents (16-22%, d.b.) and moderate sulphur contents (0.7 to partly 3%). The calorific values are normally between 25 and 27 MJ/Kg (6,000 to 6,500 Kcal/Kg). There are also some coking coals reported in the more north easterly situated Lunno and Lukusashi valleys which are, however, difficult to access (12) and consequently of potential longer-term interest only.

106. Zambia invested the Maamba coal mine in the South of the country near the Lake Kariba approximately 20 years ago and formed its own operating company. The development of this mine is of specific interest to the assessment of Southern African coal mining since it appears to be unique in the endeavour to operate a medium sized openpit with the required expensive investment (Drag line operation) and continuously needed imports of spareparts without employing an experienced management core group of a resourceful coal mining operator company.

107. The mine was set up by the National Coal Board of Zambia in 1966. Production was started in 1967. Plant design and process design were obtained by a consulting company. The Maamba Collieries Limited, MCL, was formed in 1971 which became a subsidiary of the Zambia Industrial and Mining Corporation ZIMCO, 1979. The planned capacity and initial outfit was for 1 Million tonnes coal production per year. This figure has not been achieved to-date. While in 1979, 588 thousand tonnes were produced, in 1984 production had deteriorated to 483 thousand tonnes and will probably further decline in 1985 (25).

108. A major rehabilitation programme has been designed by MCL in co-operation with an internationally experienced consulting and mine management group. The African Development Bank in co-ordination with the World Bank will finance the rehabilitation programme of more than 100 Million dollars. The rehabilitation will encompass:

- rehabilitation and replacement investments for a mine capacity of 850,000 tonnes per year;
- the rehabilitation of management performance and
- the rehabilitation of foreign exchange appropriations, which will be an important precondition for the success of the entire programme.

109. As indicated in Table 1, it is expected that the production objective of 850,000 tonnes per year will be achieved by 1990 at the latest. While the present shortcomings are partly being made up by coal imports from Zimbabwe, it is expected that by 1990 these imports will not anymore be necessary (with the exception of certain quantities of coke) and that Zambia will become a coal exporter to neighbouring countries (specifically to Zaire).

110. The present preparation treatment process for Maamba coals is resulting in some coal losses which are stored in the waste dumps. Studies are underway to utilize these discards for the manufacturing of smokeless briquettes to be used instead of charcoal and woodfuel in households and small industries. This tudy programme is of specific importance in view of the excessive use of charcoal and woodfuel, contributing to increased deforestation and desertification, specifically around major villages and towns. The results of these studies will be of interest also to neighbouring countries in Southern Africa where similar problems are encountered (e.g. Zimbabwe and Botswana).

3.1.9 Zimbabwe

111. Zimbabwe appears to be one of the coal richest countries of Southern Africa. This applies likewise to the extensive coal resources, which have only partly been explored, as well as to the excellent coal qualities and to the successfully operating mines, both openpit and underground.

112. The major coal resource areas in Zimbabwe are:

- The Zambesi Basin in north-western Zimbabwe, and
- The Sabi-Limpopo Basin in southern Zimbabwe.

113. The quantities of the reserves and resources have recently been assessed and summarized (18, 19, 20). The tremendous opencast potential of proven, probable and indicated and inferred reserves is amounting to 1.9 billion tonnes of coal on situ (4.7 billion are in table 1 as mineable) of which the Wankie Colliery present license area contains alone more than 400 Million tonnes. The underground mineable potential is likewise tremendous. Wankie has more than 35 Million tonnes proven reserves and 1.3 billion tonnes underground mineable reserves of the categories proven, probable and indicated). The overall potential is deemed to be far in excess of 11 billion tonnes in situ.

114. The coal quality data vary widely according to the many different coal areas and fields. Basically, the Wankie coal seam of approximately 20 m thickness can be subdivided into a 10 m upper part of mudstone and carboniferous shale with high volatile coal (29% d.b.) and high ash content (approximately 60%. This material is mined together with overburden but separately stored if possible for eventual later utilization.

115. The lower 10 m of the coal seam can be subdivided into 5 m steamcoal at the top, containing 25-28% volatile matter content, 25% ash a sulphur content of up to 3% and a calorific value of approximately 24 MJ/Kg (5,700 Kcal/Kg). At the bottom of this 10 m slice of the mighty Wankie coal seam is the coking coal situated at approximately 5 m thickness. Its quality in situ is 28% volatile matter content, 11% ash, up to 3% sulphur and 0.015-0.03% phosphorus. This coal is screened and washed in a simple heavy media bath and centrifugal preparation plant, also using baum jigs, to a sales product quality of 28% Volatiles, 10% ash, less than 1% sulphur, 0.015% phosphorus and an FSI value of 4. The M40 value of the coke is 68% and the M10 figure 12-13%.

116. This coking coal is being delivered to ZISCO's steel works at Redcliff and to further customers in neighbouring countries. Wankie Colliery is producing its own coke as well, however, during the next year, operations will be suspended due to a major rehabilitation programme. The customers will be supplied by coke from Wankie's corporate affiliations until production will be taken up again after commissioning of the new coke ovens early in 1987 (21).

117. Zimbabwe coal has been mined in greater quantities since the turn of the century (1903: 42,520 tonnes) and can be regarded as the oldest, most experienced coal development in Southern Africa outside South Africa. Since the mid 1950, there have been more or slightly less than 3 million tonnes per year produced at Wankie, with the peak of production in 1976 at 3,678,776 tonnes.

118. Wankie Colliery is presently the only Southern African coking coal producer (besides RSA) with coke output for mainly Zimbabwean and Zambian consumers of presently 146,266 tonnes (in 1984). The peak of coke production was reached in 1974 with 407,802 tonnes.

119. The Wankie coal mines are gassy. A disastruous Methan and coal dust explosion occurred in the No. 2 mine on 6 June 1972, and subsequently, the then existing small opencast operation was expanded.

120. Today, the No. 3 underground mine is producing about 65,000 tonnes per month, i.e. 780,000 tonnes per year, and the newly established opencast is able to produce 3 million tonnes per year. However, production was curtailed in 1984/85 due to an explosion in the Hwange Power Station (Stage I) during trial runs that delayed final commissioning of the new power station and consequently deferred openpit coal production at capacity.

121. Due to these conditions, overall run of mine production in Wankie was only 3.1 million tonnes in 1984, while the overall capacity is now according to the expected requirements of the power station Stage 1 (480 MW) 1.6 million tonnes steam coal per year plus 2.2 million tonnes coking coal per year, i.e. 3.8 million tonnes overall capacity.

122. The investment for the 3 million tonnes opencast mine was Z.$121 million (21) for Stage I in 1983 (this corresponds to Z.$31.8 per annual tonne) and would require only additional Z.$2 million for the expansion to Stage II (for 920 MW) requiring 1 million tonnes steam-coal per year more, i.e. 2.6 million tonnes overall steamcoal production. This corresponds to 4.8 million tonnes overall production and to a specific investment figure of only Z.$25.6 per annual tonne ROM capacity (1983 figures; 1 Z.$ = 0.63 US$ in August 1985). These figures compare favourably in world comparison and indicate an advantageous competitive situation of these coal resources as energy and coking plant feedstock.

123. Zimbabwe does not intend to develop a coal export potential for overseas markets in the foreseeable future, partly due to the results of the meanwhile completed transportation study of a European Consulting Company (35).

124. Zimbabwe is continuing the activities on gasification studies with the aim of an ammonia from coal project, as recommended by an international group of consultants. Further exploration work will be concentrated only on specifically low sulphur coking coal deposits for the production of special coke which must be imported for specific foundry purposes from South Africa at present.

125. Wankie's coal reserve situation appears to be more than adequate in order to serve the country's foreseeable requirements. The overall in situ coal reserves of the Wankie concessions amount to 1.7 billion tonnes of coal. Of this 472 million have coking properties. Even if Wankie's production went up to 6 million tonnes per year, the deposit remained underutilized. Consequently, no new development is really required now.

126. The Zimbabwe Ministry of Mines is, as in Zambia, pursuing a briquetting project. Such a project looks specifically promi because parts of the upper 10 m of the Wankie seam contain combustible material (60% ash) which are handled by the dragline anyway and could be suitable for beneficiation and briquetting.

127. Finally, a short reference should be made to the interesting and very simple lay out of the Wankie Colliery No. 3. This is an instructive example for the viability of a small to medium sized underground mining operation where operating costs can be minimized applying a minimum of investments and equipment installations. Such low cost mining, if effectively managed, can successfully compete with highly mechanized mines of similar production dimensions.

128. The necessity of mechanization in African underground mines appears merely to arise out of a growing production size, i.e. more than 700-800,000 tonnes per year, rather than by reasons of cost optimization. In larger mines the safety problems connected with large labour crews moving into and out of an underground coal mine, force the mine planner to increase the degree of mechanization in order to increase performance per manshift and consequently to reduce the number of underground labour force. The final cost effect of increasing performance from 2.4 tonnes per manshift in a hand got operation in Zimbabwe to e.g. 7.5 tonnes per manshift in a conventionally equipped mechanized operation in another southern African country (using loading machines and shuttle cars) appears to be negligible in the observed cases. The savings in labour costs appear to be made up by additional costs for capital repayments, debt service and higher material and energy costs. The result of costs per tonne of ROM coal is in both cases, hand got and conventionally mechanized, in fact, very similar.

129. A qualification has, however, to be made with respect to the general level of labour costs in a country. In industrialized coal producing countries as e.g. in Europe, North America, Australia or to a lesser degree also in South Africa, the general level of average labour costs for underground mining appears to be higher than in developing countries covered by this report. It goes without saying that the level of labour costs determines the treshhold, when mechanization commences to make sense.

130. This complex of realistic cost optimization appears to be of specific importance with respect to the proper advice to be given to African countries in their endeavour to develop their own coal resources for indigenous consumption and for the substitution of excessive woodfuel consumption around towns and villages, where small-scale mines (100-300,000 tonnes per year) would be sufficient to serve the issue.

131. Wankie coal is offered in the Southern African market in many quality brands and size fractions. The major prices are presently:

- for Dry Coal Z.$/t 23.00
- for Washed Coal Z.$/t 26.50
- for Coking Coal Z.$/t 42.20

According to the annual report 1985, in 1984/85 (end of Wanki's fiscal year 28 February 1985) was the annual turnover Z.$74,384,000. The overall sales tonnage was 2,421,190. This results in an average sales price for sold coal of approximately Z.$30 per tonne. The margin during the last year was, despite the mentioned operational constraints, sufficient in order to capitalize a major amount for foreign exchange losses, to make appropriations for capital and other reserves and to pay a healthy dividend to shareholders.

132. The Zimbabwe Government is the major shareholder of the Company*. The overwhelming parts of the profits of the other shareholders are pledged to be reinvested in the country for many years. This enterprise, mainly by virtue of its management, conducted according to basically unchanged private-economic principles, will be a guarantor of lasting success for the generating of revenues that are urgently needed for the further development of the country.

133. It appears that the structure of Wankie Colliery could serve as an advisable example how coal mining can successfully contribute, not only to substituting woodfuel and oil consumption, but also to generating precious additional values which are successfully serving the country's development.

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*Distribution of ownership:
- Anglo American 20%
- Government of Zimbabwe 40%
- Individuals and Institutions approx. 40%

3.8 South Africa

134. It would exceed the framework of this study, if a detailed description of South African coalmining economies were to be attempted here. Authentic international publications (8, 9, 10, 11 a.e.b) are available dealing with South Africa's coal mining industry which is ranking fifth (after Poland) in a world comparison of the leading coal producing countries in 1983 (34);see also ("World Coal", Vol. 7, No. 7 Nov./Dec. 1981) (32). Of the overall world coal production of 2,826.5 million tonnes in 1980, South Africa's share in 1983 with 146.1 million tonnes was 5.2%. This production is achieved by 86 operating collieries.. In 1985 production will increase to 165 million tonnes. The predictions for 1990 are reaching a figure above 200 million tonnes annual production (8,11). In 1983, there were 65,000 people employed in coal mining.

135. The quantities of South African Permian coal reserves appear to be likewise very high with 58 billion tonnes mineable reserves, however, in comparison to the established coal reserves in other African countries it must be stated that exploration activities have much more progressed in South Africa in the past, yielding higher figures for known reserves, than in other African countries. The rapid growth of the reserve figures in the developing African countries during recent years shows that there might still be great unexplored coal potentials to be disclosed. This is also recognizeable from Figure 1, where the resources in situ show already a more favourable relation for developing countries vis-à-vis South Africa than the mineable reserves do.

136. The qualities of South African coals are similar to those of other Southern African countries. However, the in situ resources which are ranging from Anthrazite to high volatile, are partly be beneficiated in order to comply with local requirements and with international coal trade demands. Often, various products are the results of coal washing:

- Metallurgical coal for steel production or exports,
- Steam coals for industries and exports, and
- Power station coals for indigenous power generation.

The ash contents are thereby ranging between 6 and 16%, the sulphur remains mostly under 1% and the calorific value is ranging between 23 and 33 MJ/Kg (5,500 - 7,900 Kcal/Kg) (34). Some power station coals, if raw coal or discards are burned, show much higher ash contents and lower calorific values. The calorific value of power station coals declined in the average during the last 20 years from 27 MJ/Kg to 17 MJ/Kg, indicating, the increased use of discards and low calorific coals (36).

137. The major part of South African coal production (1981) (11) is sold to power plants (46%), the next largest portion goes to exports (23%); industries (including synfuels, chemicals, agriculture, etc.) consume 18%, metallurgical purposes take 7%, and the remainder is distributed among transport, mining and other domestic consumers.

138. The performances in South African coal mines are, as in other Southern African coal mines, dependent on the degree of mechanization. During the last decade, there was a steady increase from averaging 3.5 tonne per MS in 1970 to more than 6t per MS in 1980 (averaging over all coal mines in Transvaal and Orange Freestate)(33). Today, the average figure for South African coal production performance is exceeding 12 t per MS (34). While in 1970 still 57% of all operations were using hand loading, in 1980 this figure went down to only 10% and is expected to further decrease towards 1990 to 4% (33). Mechanized loading, continuous mining, long walling and open cast mining will play an ever growing role in coal production, as it does in many other regions in the world. The growing performance figures are being matched by steeply rising labour costs per man shift and enable the industry to remain competitive in world scale.

139. South Africa is ranking as the world's fourth largest coal exporter after U.S.A. Australia, and Poland. While coal exports were still low in 1970 at only 1.5 million tonnes, with the construction of the Richards Bay coal terminal at the Indian Ocean in the mid seventies, the export figure accellerated in 1976 to 6 million tonnes and to 29 million tonnes in 1980. There are 40 million tonnes expected in 1985 (40) and 65 million in 1990 (11, 12).

4. SUMMARY AND ASSESSMENT

140. The numerical results of the inventory are summarised in Table 1. The reader is kindly requested to critically check the figures with respect to his own country and to convey his possibly diverting information or opinion back to the author. It appears to be obvious that the attempted inventory after only one year's work cannot stand up to scruting in every respect. This presentation is meant to start "the ball rolling" in order to obtain the required feedback from African member States. As mentioned in the introduction, it is intended to revise this inventory by the year 1987 when more comprehensive information will have been obtained.

141. Figure 1 shows the summarized resource figures subdivided in-

- mineable reserves, which contain (according to the US Bureau of Mines classification) proven, probable, and indicated reserves which could under prevailing technical and economic conditions in principle be developed for exploitation;

- Resources in Situ, which in addition contain the geologically possible reserves and

- The Total Resource Potential, which under sound geological assumptions include also a resource potential which is deemed to be in place, but for which no exposures have been found yet. It appears to be in the nature of such an assessment that this figure must be dealt with in a tentative and cautious way and that rather conservative figures are inserted for the time being than courageous assumptions.

142. As mentioned in the proceeding section, the mineable reserve figure for developing African countries appears to be rather small in comparison to the mineable reserves in South Africa. This is assessed to be mainly a function of the degree of established exploration work, in which the developing countries have to catch up according to their specific requirements. The graphs for resources in situ and for total potential (Figure 1) illustrate, that relatively more coal resource potential is available in developing countries than as indicated by the graph for mineable reserves.

143. These graphs show, clearly that the Southern half of Africa possesses much more coal resources than the northern part of the continent. This appears to be a general indication for the chances which the intra-African trade may have in the future, when the abundant Southern African coal resources will have been developed for export purposes.

144. Generally speaking inverse conditions appear to prevail with respect to the potential for hydrocarbons, which phenomenon may help to facilitate the development of intra-African trade with bulk commodities in the future.

145. The African Coal Production - Exports and Imports are displayed in the bar charts of Figure 2. These figures demonstrate the early stage of the developing African countries' coal production build-up. While the SADCC countries expect a steady growth, the production figures of North African countries are of smaller order of magnitude.

146. Comparatively small are also the expectations for coal exports of developing countries until 1990. There are partly geographical reasons for this, e.g. in Zimbabwe and Botswana. But political reasons play an important role too, as e.g. in Mozambique where major coal reserves wait for export development.

147. Figure 3, where a ten times larger vertical scale is applied, demonstrates these conditions more instructively. Of specific interest and concern appear to be the steeply growing coal import figures for some north African countries and for Nigeria. The efforts in these countries to increase or to establish indigenous coal production are recorded in the respective sections. However, as mentioned above, the much smaller reserve and resource potentials in northern African countries do not offer too optimistic expectations. Somehow more positive opportunities are obviously existing in Nigeria, where a coal production rehabilitation effort appears to be initiated in order to satisfy the growing demand and to restrict expensive foreign currency imports of coking coals for the newly established steel industry.

148. The intra African trade opportunities evolve also from the forecasted coal imports as indicated in the graphs of Figure 3 whereby the North African countries will be the main potential intra African coal importers for steam and coking coals. As mentioned above, the southern and eastern African countries are the potential coal exporters for steam and coking coals. The most favourable conditions are noticeable in Mozambique, but probably also in Madagascar from a logistical point of view and - in the case of Mozambique - from the aspect of favourable coal qualities. Unfortunately, the infrastructural preconditions (rail, harbour) are not yet existing and will require major investments. These, on the other hand, necessitate major quantities for coal exports in order to secure payback of these costly investments. Major quantities, however, require certain minimum technical managerial and politico-economic conditions, which are partly not yet prevailing in some of these countries.

149. The result will have to be a major effort on the side of the concerned developing countries to create the required pre-conditions predominantly in respect of educated, trained and experienced managerial manpower in order to co-ordinate and to monitor major feasibility and coal development projects. Close co-operation with industrialized countries which may have an interest in such developments appears to be part of the answer. Overseas coal consumers may be the group of donor - and co-operation partners to be approached. This, however, should not exclude the intensified co-operation between interested African States.

150. Education and training of managerial personnel requires a long term approach. Successful examples have been established by commonwealth members for the education and training of mining engineers in developing countries. The experiences gained by these models could be helpful for such further co-operation with other industrial countries. Also subregional institution building for education and training appears to be one of the required measures.

151. However, time appears to be of the essence, and a short-term approach can be chosen by employing experienced project - and operating managing companies in order to prevent failure and wasted monies. Instructive examples could be recognized in preceeding sections for the failed attempts of single African States to "do it yourself". The unfortunate consequence may have been expensive rehabilitation programmes, the monies which could have well be used for other more productive development purposes, if the rational attitude to employ somebody who knows how, had been prevailed in the first place. This principle does not apply only to developing country conditions, but is successfully applied all over the world in mining, especially by venture companies in free market oriented industrialized countries. Mining, and specifically coal mining, requires a high degree of expertise which is not only required to safeguard a sound return on the investment, but must be regarded indispensable for the safety of the underground labour force.

152. If this principle is applicable to large scale coal mining investments as mainly required for the establishment of export capacities, it applies also - and sometimes even more - to small or medium scale mining as required for the initially mentioned purposes of wood fuel substitution and local power generation (see Section I Background and Introduction).

153. We have seen in the inventory description of the various Southern African countries that underground mining is hazardous and led to Methan - and coal dust explosions in Mozambique and Zimbabwe (as well as in other parts of the World) in the past. Every effort must be taken to prevent such coal mine desasters in the future. The employment of experience and expertise appears to be the first step in this direction.

154. This does, not mean, however, that sophisticated, highly mechanized mining methods should be pursued for such small or medium scale underground coal mines. As described in more detail in the section on Zimbabwe, the very simple but effective lay out of the Wankie Colliery No. 3 shows that the operating costs appear to have been minimized by applying a minimum of investments and equipment installations. Such low cost mining, if effectively managed, can successfully compete with highly mechanized mines of similar production.

155. It has, to be mentioned, nevertheless, that in larger mines, as required for export purposes or large scale power generation, the safety problems connected with large labour crews moving into and out of an underground coal mine, force the mine planner to increase the degree of mechanisation in order to increase performance and consequently to reduce the number of underground labour force.

156. A qualification has, to be made with respect to the general level of labour costs in a country. In industrialized coal producing countries the level of average labour costs for underground (and openpit) mining appears to be higher than in developing countries covered by this report. It goes without saying that the level of labour costs determines the treshhold, when mechanization commences to make economic sense.

157. This complex of realistic cost optimisation appears to be of specific importance with respect to the endeavour of African countries to develop their own coal resources for indigenous consumption, for small scale power plants, and for the substitution of excessive wood fuel consumption around towns and villages, where small and medium scale coal mines would be the answer to the question of how salvation from environmental devastations and relieve from expensive oil imports can be achieved.

158. The foregoing inventory and assessment of coal resources, of production - export - and import figures, requirements and forecasts is meant to contribute to the strengthening of co-operation and mutual assistance between African States and between Africa and the industrialized world. It is meant to help initiate fast and effective action in order to overcome the pressing environmental, foreign exchange, and energy related problems which this continent is facing.

5. LIST OF REPORTS AND DOCUMENTS

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6. ABBREVIATIONS AS USED IN THIS REPORT

BMC	British Mining Consultants (affiliated to National Coal Board, UK)
BP	British Petroleum
Cbm	Cubic meter
Cby	Cubic yard
CIF	Cost, Insurance, Freight
d.b.	Dry basis
E	Emalangeni (Swaziland currency, same value in US$ as Rand)
EEC	European Economic Community
FOB	Free on Board
FRG	Federal Republic of Germany
K	Kwacha (Malawi and Zambian Currency, MK = 0.62 US$ (July 1985) ZK = 0.50 US$ (August 1985)
Kcal/Kg	Kilogram Calory per Kilogram, heat value
MC	Monten Consulting (West German Mining Consultant Company, affiliated to Ruhrkohle AG)
MIDCOR	Mining Investment and Development Corporation (Malawi)
MCL	Maamba Collierires Ltd.
MJ/Kg	Mega Joule per Kilogram ($4,18706 \times 10^{-3}$ Kcal/Kg), Heat value
MS	Manshift
MW	Megawatt, heat rating
M40, M10	Values for the Strength of Coke and for its size distribution
NCB	National Coal Board (UK)
NE	North-East

NEPA	National Electric Power Authority (Nigeria)
ROM	Run of Mine (coal)
SADCC	Southern African Development Co-ordinating Conference
t	Tonne (metric 1,000 gram)
t/MS	Performance in tonnes coal per manshift
UNDP	United Nations Development Programme
UNECA (ECA)	United Nations Economic Commission for Africa
W	Watt, heat rating
Z$	Zimbabwe Dollar = 0.63 US$ (Sept. 85).
ZIMCO	Zambia Industrial and Mining Corporation
ZISCO	Zimbabwe Iron and Steel Corporation.

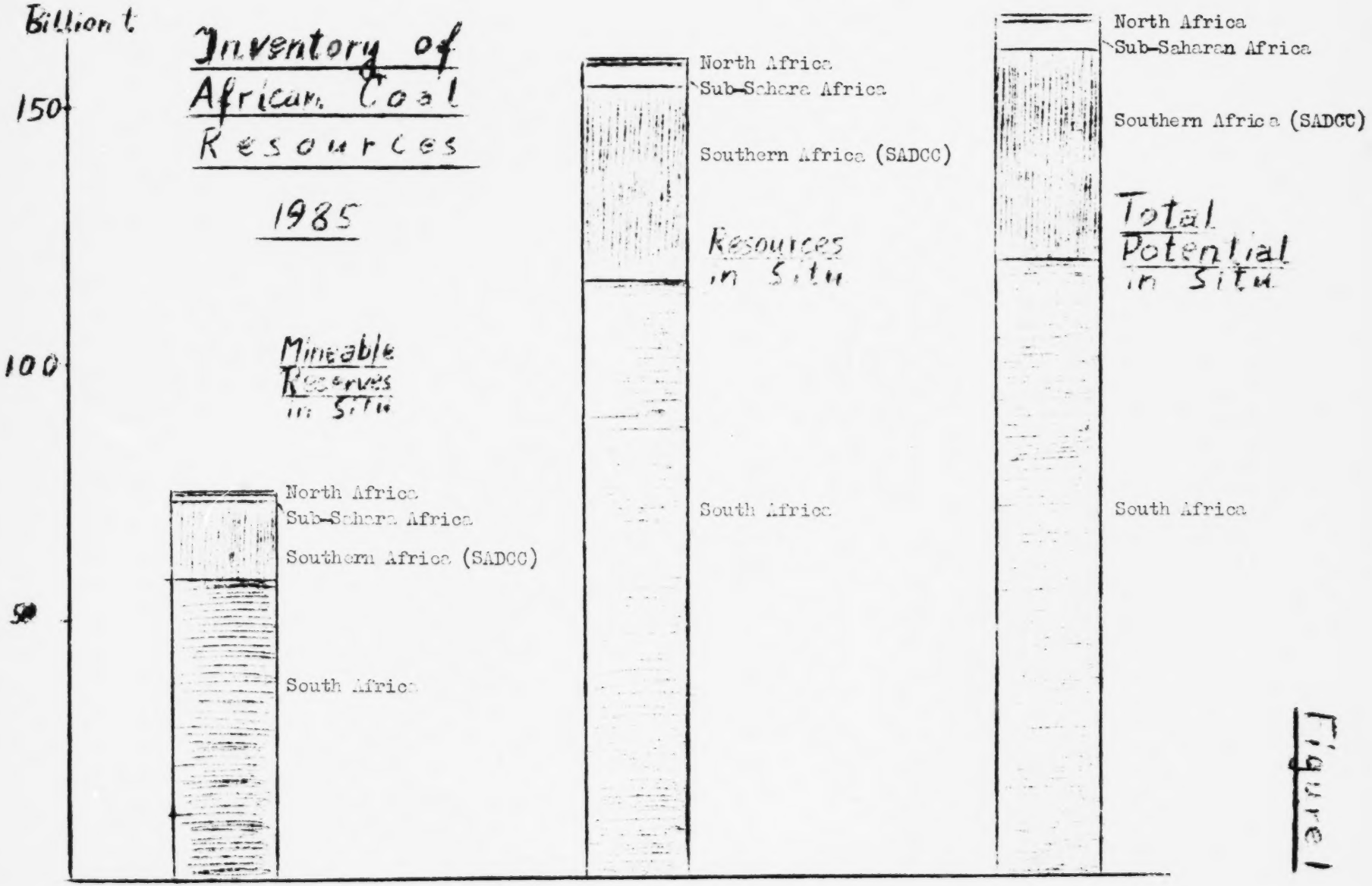
Billion t
Inventory of African Coal Resources
1985
150
100
50
Mineable Reserves in Situ
North Africa
Sub-Sahara Africa
Southern Africa (SADCC)
South Africa
Resources in Situ
North Africa
Sub-Sahara Africa
Southern Africa (SADCC)
South Africa
Total Potential in Situ
North Africa
Sub-Saharan Africa
Southern Africa (SADCC)
South Africa

Figure 1

African Coal Production, Exports and Imports

Figure 2

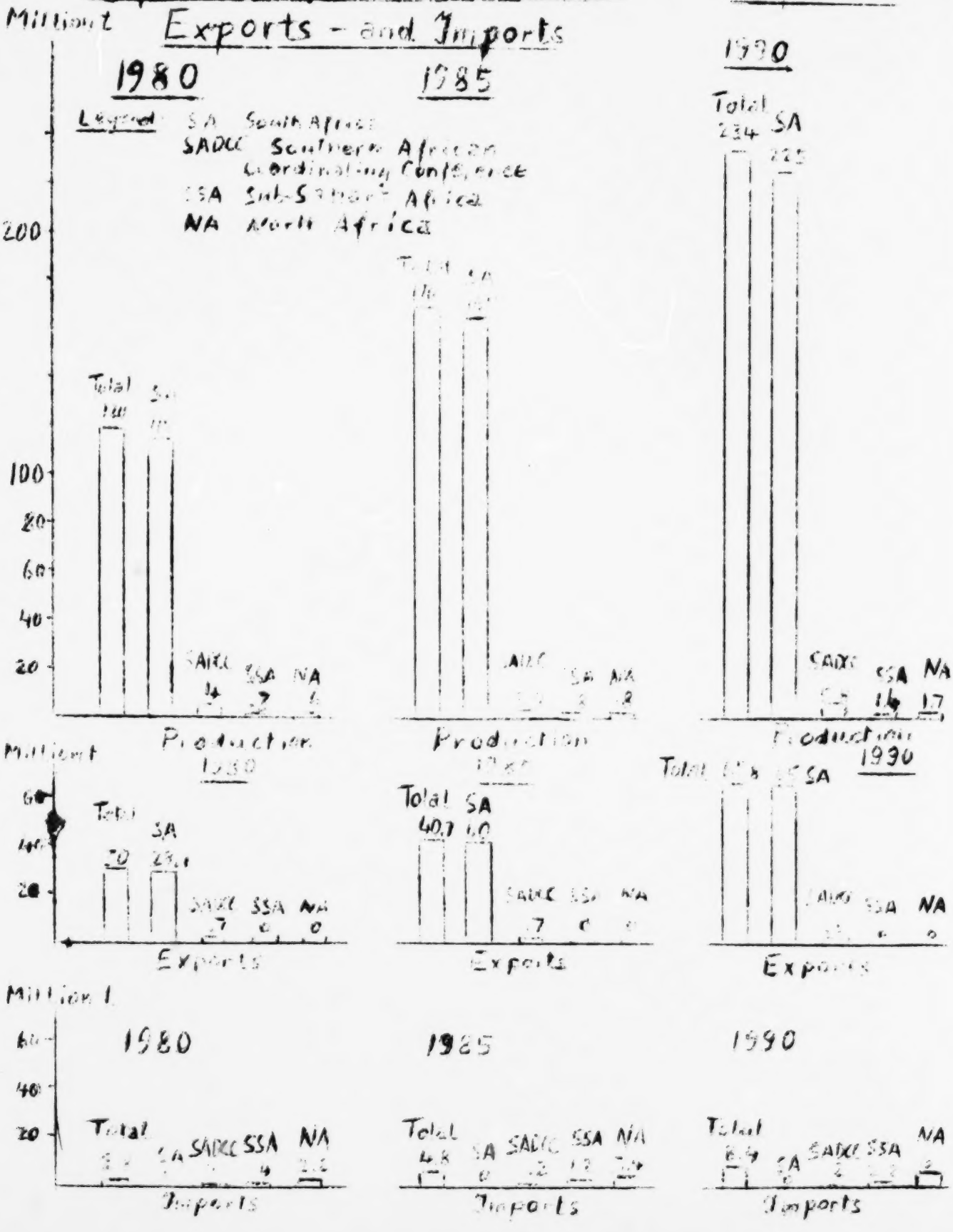

Figure 3

Developing African Coal Production, Exports and Imports